

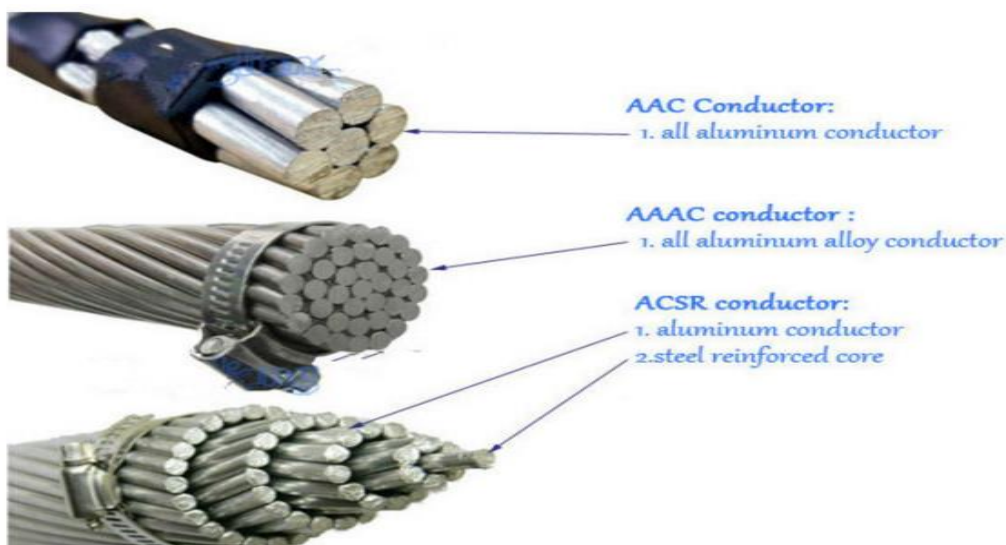
Chapter 3

Power Transmission and Distribution

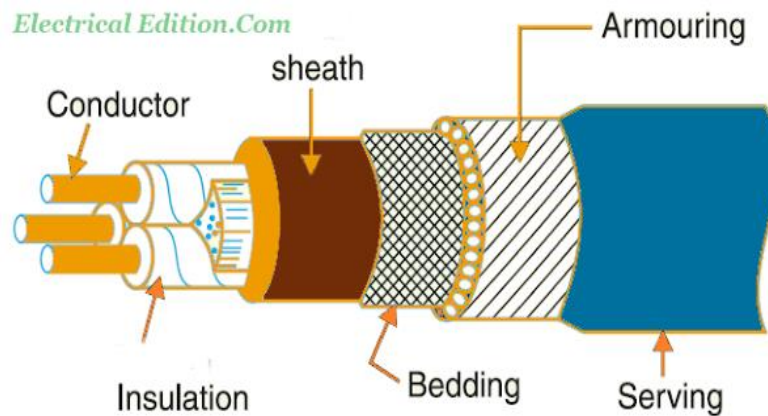
1. Electricity is generated at generating stations and is transmitted to the places over long distances where it is consumed.
2. Based on how the electrical conductors are laid, the transmission or distribution systems are known as Over Head (OH) or Under Ground (UG) systems.
3. **Overhead conductors** are generally bare electrical conductors (without insulation) supported by tall structures such as towers or poles.
4. **Underground Cables** are conductors or bunch of conductors covered with electrical insulator and are buried underground.

Overhead Cables Overhead Cables

- Number and size of strands of the conductor depends on current to be carried.
 - Strands used in place of single conductor help reduce the ac resistance of the conductor.
1. AAC: All Aluminum Conductors .High Corrosion resistance. Used for short spans. Best electrical performance but mechanical strength is poor.
 2. AAAC: All Aluminum Alloy Conductors. Good mechanical strength and electrical performance.
 3. ACSR: Aluminum Core Steel Reinforced conductors are used for better mechanical strength. Used for extra-long span.



Underground Cables



Part of Underground cable	Functions as	Material Used
Cores or Conductors	<u>Carries current.</u>	<u>Copper</u> <u>Aluminum</u>
Insulation	<u>stop the leakage of current</u>	<u>Paper</u> <u>Rubber</u>
Metallic sheath	To <u>protect</u> the <u>insulation from direct contact with the soil</u>	<u>Aluminum</u>
Bedding	It <u>protects</u> the <u>metallic sheath</u> from <u>corrosion</u> due to moisture and it <u>Acts</u> as <u>adhesive</u> to <u>stick</u> the <u>metallic sheath</u> and <u>armoring</u> .	<u>Jute</u> <u>Hessian Tape</u>
Armoring	<u>Provide good mechanical strength</u> to the <u>cable</u> and to <u>protect</u> the cable from <u>injuries</u> during <u>erection</u>	<u>Galvanized Steel Wire</u> <u>Steel Tape</u>
Serving	<u>Protect</u> <u>armoring</u> from <u>atmospheric conditions</u>	<u>Jute</u>

Particular	Overhead	Underground
Public safety	<u>Less</u> safe	<u>More</u> safe
Initial Cost	<u>Less</u> expensive.	<u>More</u> expensive
Faults	Faults occur <u>frequently</u>	<u>Rare</u> chances of fault
Appearance	<u>Shabby</u> look	Does not disturb the view as cables are <u>hidden</u> underground
Flexibility	<u>More</u> flexible as <u>new</u> conductors can be laid along the existing conductors	<u>New</u> channels are required to <u>laydown</u> new cables.
Location of fault	Fault location can be identified <u>easily</u> by <u>visual inspection</u> .	<u>Special techniques</u> are required to <u>locate</u> fault.
Repair	Repairing is <u>easy</u> and <u>less expensive</u>	Repairing is <u>difficult</u> . Requires special arrangements for joining cables.
Working Voltage	Can be used for <u>any value</u> of high voltage.	It has limitations of insulation <u>difficulty</u>

Advantages of UG Cables

1. High level of personal and public safety.
2. No bushfire problems.
3. Minimal lightning problems.
4. Not affected by ice, snow, rain, wind, dust, smoke or fog
5. Not affected by storms, hurricanes, tornados.
6. Less number of faults, hence low maintenance cost.
7. Value of land and building unaffected.
8. High reliability and availability.
9. Reduced I and D losses.
10. Low Electro Magnetic Field
11. No Corona discharge, Radio Interference, Television Interference.

Disadvantages of UG Cables:

1. Digging of continuous trench is essential.
2. Presence of vaults and manholes.
3. High cost of installation.
4. High cost of Maintenance and repair as cables and their installation is expensive.
5. Longer outage time to locate fault and repair.
6. Soil thermal conditions are modified.

Corona Discharge:

1. The phenomenon of violet glow, hissing noise and production of ozone gas in an overhead transmission line is known as corona.
2. Partial discharge of electrical energy which causes the ionization of air close to the conductors in Extra High voltage (EHV) transmission lines is known as Corona Effect.

Factors Affecting corona:

1. Line voltage
2. Spacing between the conductors
3. Conductor Size
4. Atmospheric conditions

Methods of reducing corona effect:

1. By increasing conductor size
2. By increasing conductor spacing

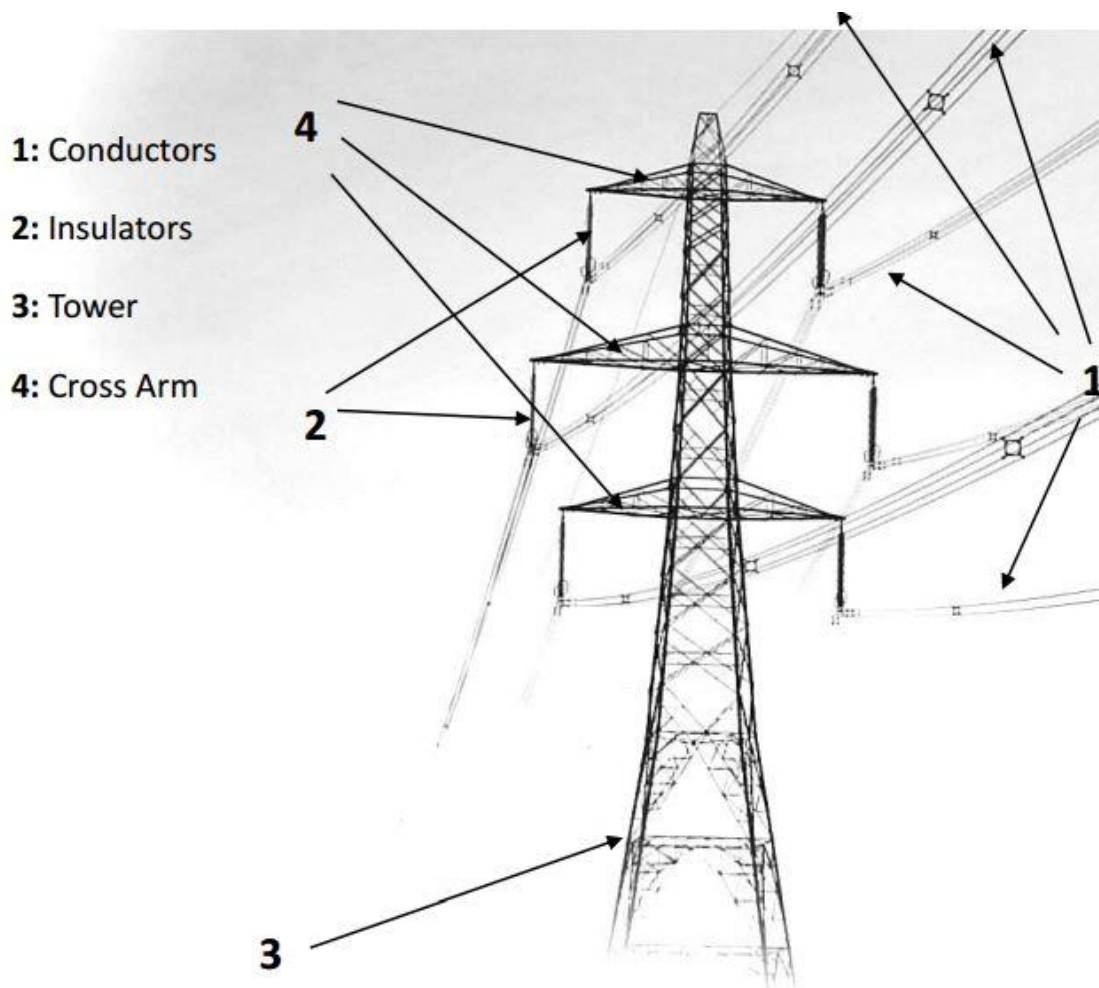
Advantages of corona:

1. Due to corona formation, the air surrounding the conductor becomes conducting and hence virtual diameter of the conductor is increased. The increased diameter reduces the electrostatic stresses between the conductors.
2. Corona reduces the effects of transients produced by surges.

Disadvantages of corona:

1. Corona is accompanied by a **loss of energy**. This affects the transmission **efficiency** ↓ of the line.
2. **Ozone** is produced by corona and may **cause corrosion of the conductor** due to **chemical action**.
3. The **current drawn** by the line due to corona is **non-sinusoidal** and hence non sinusoidal voltage drop occurs in the line. This may cause **inductive (flux) interference with neighboring communication lines**.

Components of Overhead Transmission Line



Supporting Structure: Towers and Poles

The supporting structure must have following properties

1. **High mechanical strength** to support the **weight** of the conductor.
2. **Light in weight** to be transported easily.
3. **Cheap in cost** and **economical** to use and maintain.
4. **Longer life**
5. **Easy accessibility** of conductors for maintenance.



6. Steel Towers
 - Wooden Poles
 - Steel Poles
 - Concrete Poles

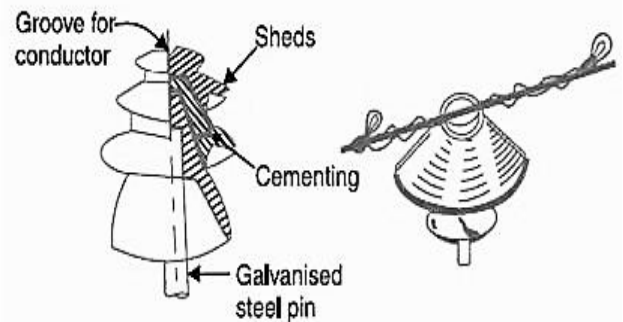
Insulators:

The insulators provide necessary insulation between **line conductors** and **supports** and thus **stop any leakage** current from conductor to earth.

The insulators should have following properties:

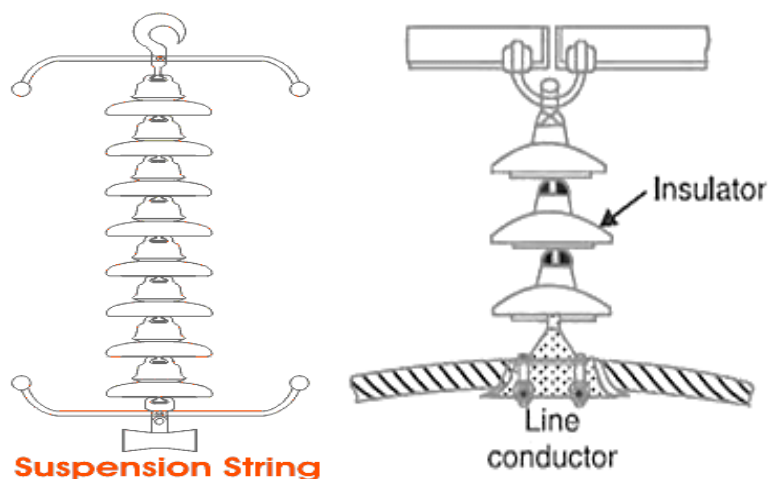
1. **High** electrical **resistance** to avoid any **leakage current**.
2. **High relative permittivity** (ϵ_r) so as to reduce **capacitance effect**.
3. **High mechanical** strength in order to **withstand** conductor load and wind load etc.
4. **Non-porous**, free from **impurities** and **cracks**.
5. Able to **withstand** severe **atmospheric** conditions such as **heat** and **moisture**.

1. Pin Type Insulator



1. There is a **groove** on the **upper end** of the insulator for **housing** the **conductor**.
2. The conductor passes through this **groove** and is bound by wire of **material same as that of the conductor**.
3. These are used for **transmission** or **distribution** lines up to **33kV**.
4. For voltage **more than 33kV** the pin type insulators become too **bulky**.

2. Suspension OR Disc Type Insulator



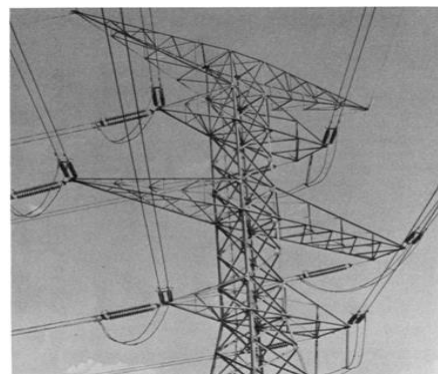
1. These have **number of porcelain discs** connected in **series** by **metal links** in the form of **string**. The **conductor (lower)** is suspended at the **bottom** end of the string while the other end of the string is fixed to the cross **arm** of the tower (upper) .
2. If anyone **disc is damaged**, only the damaged one is **replaced**.
3. Generally each of the **discs** is designed to withstand **11 kV**.
4. Offers **flexibility** to the line to reduce **mechanical stresses**.
5. These are **cheaper** than pin type **insulators** for voltages more than **33kV**.

3. Shackle OR Spool Type Insulator



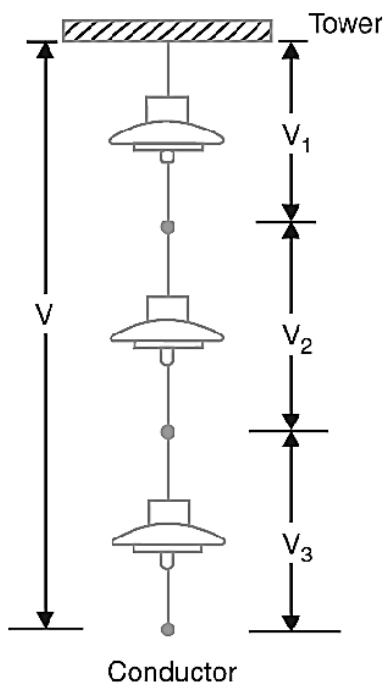
1. These are the insulators used where there is a dead end of the line or there is corner or sharp curve.
2. Shackle insulators are used as strain insulators for voltages up to 11 kV.

4. Strain Type Insulator



1. Where there is a dead end of the line or there is corner or sharp curve, the line is subjected to greater tension. In order to relieve the line of excessive tension, strain insulators are used.
2. For low voltage lines shackle insulators are used as strain insulators. However for high voltage transmission lines, suspension insulators are used as strain insulators.
3. When the tension is excessively high, two or more strings are used in parallel.

String Efficiency



1. Voltage across the string of suspension insulators is **not uniformly distributed across the individual discs.**

2. The **disc nearest** to the **conductor** has **highest voltage** across it whereas the **disc** attached with the cross **arm** has **lowest voltage.** $V_1 < V_2 < V_3 < V_4$

3. This phenomenon is undesirable and is expressed in terms of **string efficiency.**

4. String efficiency is improved by using **longer cross arms**, by **grading the insulators**, by **using a guard ring.**

$$\text{String Efficiency} = \frac{\text{Voltage across the string}}{n \times \text{Voltage across disc nearest to the conductor}} \times 100$$

$$\eta = \frac{(V_1 + V_2 + V_3)V_{ph}}{n \times V_3} \times 100$$

Where, **n = number** of discs in the string

1. A 3-phase transmission line is being supported by three disc insulators. The potentials across top unit (i.e., near to the tower) is 8 kV, middle unit is 11 kV, and lowest unit is 18.12 kV. Calculate

1. Voltage across string.

2. Line voltage

3. String efficiency.

2. A three phase transmission line is being supported by 4 disc insulators and the total voltage across the string is 30 kV. The potentials across top unit (ie: disc nearest to tower) is 6kV, next disc is 8 kV and lowest unit (i.e.: disc nearest to conductor) is 9 kV.

Find:

1. Disc voltage
2. Line voltage
3. String efficiency.

3. If the string efficiency of a three phase transmission line is 70% and it is supported by 5 disc insulators. The potentials across top unit (i.e.: disc nearest to tower) is 5kV, next disc is 7kV, next disc is 8 kV, and lowest unit (i.e.: disc nearest to conductor) is 12 kV. Find

1. The voltage between line and earth

2. Line voltage

3. The disc voltage.